



2023 DRAFT COASTAL MASTER PLAN

# OVERVIEW OF IMPROVEMENTS TO RISK MODELING

APPENDIX E

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COASTAL PROTECTION AND  
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# COASTAL PROTECTION AND RESTORATION AUTHORITY

This document was developed in support of the 2023 Coastal Master Plan being prepared by the Coastal Protection and Restoration Authority (CPRA). CPRA was established by the Louisiana Legislature in response to Hurricanes Katrina and Rita through Act 8 of the First Extraordinary Session of 2005. Act 8 of the First Extraordinary Session of 2005 expanded the membership, duties, and responsibilities of CPRA and charged the new authority to develop and implement a comprehensive coastal protection plan, consisting of a master plan (revised every six years) and annual plans. CPRA's mandate is to develop, implement, and enforce a comprehensive coastal protection and restoration master plan.

## CITATION

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# LIST OF ABBREVIATIONS

ADCIRC .....	ADVANCED CIRCULATION MODEL
CLARA .....	COASTAL LOUISIANA RISK ASSESSMENT MODEL
CPRA .....	COASTAL PROTECTION AND RESTORATION AUTHORITY
DEM .....	DIGITAL ELEVATION MODELS
EAD .....	EXPECTED ANNUAL DAMAGES
EADD .....	EXPECTED ANNUAL DAMAGES IN DOLLARS
EASD .....	EXPECTED ANNUAL STRUCTURAL DAMAGE
ERDC .....	ENGINEERING RESEARCH AND DEVELOPMENT CENTER
FEMA .....	FEDERAL EMERGENCY MANAGEMENT AGENCY
HIFLD .....	HOMELAND INFRASTRUCTURE FOUNDATION-LEVEL DATA
HUD .....	DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
ICM .....	INTEGRATED COMPARTMENT MODEL
JP-MOS .....	JOINT PROBABILITY – OPTIMAL SAMPLING
NSI .....	NATIONAL STRUCTURE INVENTORY
MDT .....	MASTER PLAN DELIVERY TEAM
MVN .....	USACE NEW ORLEANS DISTRICT
SWAN .....	SIMULATING WAVES NEARSHORE MODEL
USACE .....	UNITED STATES ARMY CORPS OF ENGINEERS
USGS .....	UNITED STATES GEOLOGICAL SURVEY



# 1.0 INTRODUCTION

As was done for the 2017 Coastal Master Plan, the 2023 Coastal Master Plan development efforts leveraged and improved existing models, data, and tools. The Coastal Protection and Restoration Authority (CPRA) built upon existing technical tools and approaches developed for previous master plan risk modeling efforts with targeted updates and improvements. This continuous improvement ensures consistency in the planning process while incorporating state of the art modeling and the most current available baseline data.

A major improvement to the modeling suite included aligning the geographic extents of the associated model grids (i.e. ICM, Census Block, CLARA, Community, etc.). This facilitated a more seamless transfer of model inputs and outputs between models and supported consistent interpretation of results.

Additionally, the 2023 Coastal Master Plan evaluated additional measures of risk in order to support a more equitable evaluation of the mitigation potential of coastal protection and restoration investments. Prior measures of risk and risk mitigation have focused on the monetary value of damages and losses. The 2023 Coastal Master Plan investigated not only these traditional measures of risk, but also evaluated risk in terms of damages to coastal structures. Since these are largely residences which can vary greatly in value, this measure supported a more consistent evaluation of surge risk across the coast and allowed for that evaluation in terms more in line with the effects of residents' lives.

The development of the 2023 Coastal Master Plan offered many opportunities to update and improve the suite of models and data sets that support estimating and predicting risk due to tropical system storm surge. These include the surge and wave models, the damage and risk models, and the methodologies used to evaluate the effectiveness of nonstructural risk mitigation.

## 2.0 IMPROVEMENTS TO SURGE AND WAVE MODELS

The 2023 Coastal Master Plan uses Advanced Circulation (ADCIRC) and Simulating Waves Nearshore (SWAN) modeling to simulate the impact of hurricanes on current and future landscapes with and without coastal restoration and protection projects. Prior to the initiation of the 2023 Coastal Master Plan, the ADCIRC storm surge model and SWAN spectral wave model was updated to address for advancements in storm research and model advancements. This was done in coordination with other entities that perform storm surge modeling in Louisiana to ensure that they use a common set of assumptions about the underlying physics to allow for consistency across studies. These entities included: CPRA, United States Army Corps of Engineers (USACE) Engineering Research and Development Center (ERDC) Coastal Hydraulics Laboratory, Louisiana State University, and USACE New Orleans District (MVN).

To ensure that the surge models results are consistent with what would be expected, a variety of model parameters including air-sea drag parameterization, limits for bottom roughness, river flow rate, and offshore initial water levels, were evaluated against historical storms. Figure 1 shows the storm tracks and central pressures that were used in evaluating the model parameters. The model outputs were evaluated against observed data to inform the selection of the most appropriate parameterization. Details are available in Attachment E1: Storm Surge and Waves Model Improvements.



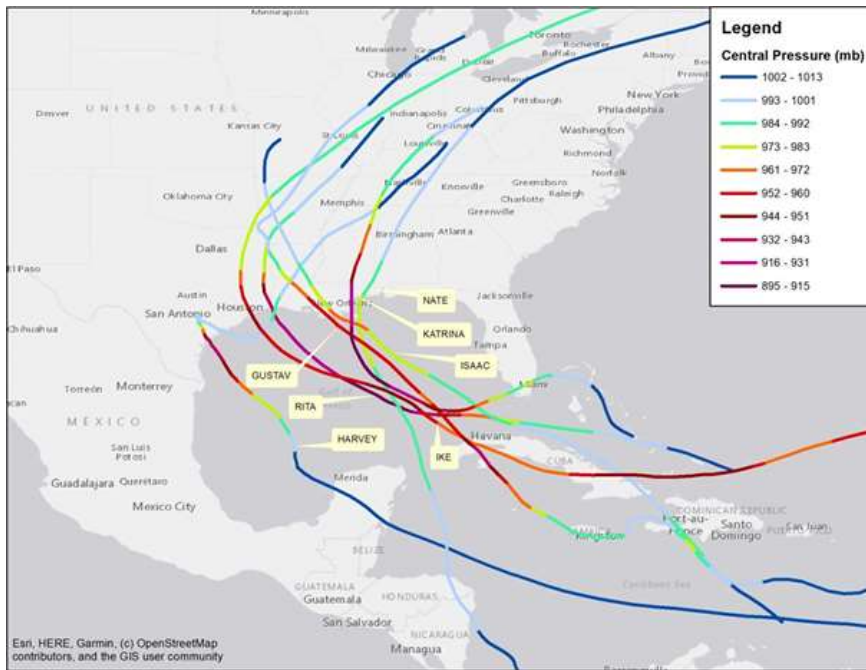


Figure 1. Storm tracks and central pressure used in model parameter analysis.

Working with ERDC/USACE, an updated set of storms developed using the USACE's Joint Probability – Method – Optimal Sampling (JPM-OS) for tropical storm surge was used to model hurricanes and tropical storms and evaluate associated damages in Louisiana. This updated storm suite incorporated both more extreme and less intense storms than were previously available. The new set of synthetic storms developed by ERDC consists of 645 storms that span a wider range of the possible Atlantic cyclone parameter space than the previous set of 446 storms. For example, central pressures at landfall range from 1005 mb to 86.5 mb, representing everything from minor tropical depressions to Category 5 hurricanes, including considerably stronger storms than have ever been observed in the Atlantic Basin. Storm tracks were developed to span the entire Gulf region (Figure 2).

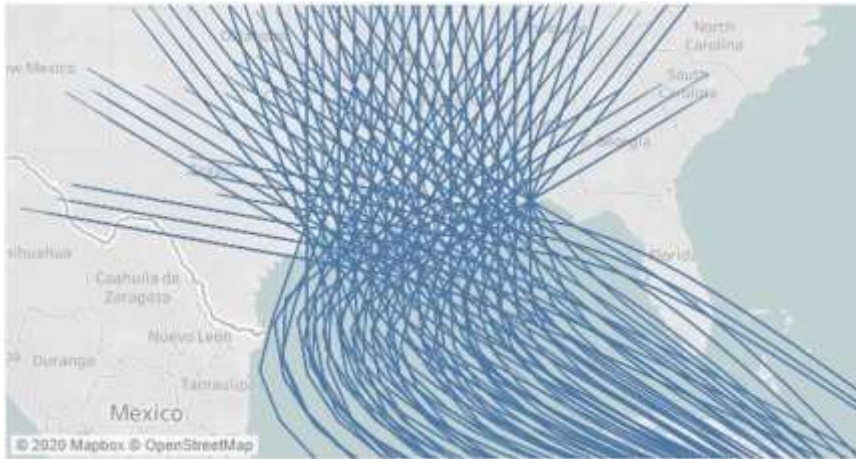


Figure 2. Storm tracks in the ERDC 645 storm suite.

The sheer number of these storms makes it impossible to simulate them all individually against the range of time periods, scenarios, and project meshes that are used in developing the master plan. The master plan team worked with ERDC to implement a sampling technique to reduce the required storm set to 95 storms while not introducing excessive inaccuracy in the surge depths or depth exceedances. Details are available in Attachment E2: Risk Assessment Model Improvements. This reduced storm set allows the 2023 Coastal Mater Plan to cover the complete range of potential storms and their effects with a reduced set of storms that can be realistically modeled against the wide range of future possibilities required for planning purposes.

# 3.0 IMPROVEMENTS TO THE DAMAGE AND RISK MODELS AND DATA

The master plan team uses the Coastal Louisiana Risk Assessment (CLARA) model to evaluate current and future risk due to storm surge. CLARA was originally developed for the 2012 Coastal Master Plan by the RAND Corporation. CLARA is designed to estimate flood depth exceedances, direct economic damage exceedances, and expected annual damage (EAD) across the Louisiana coastal zone. The model uses high-resolution hydrodynamic simulations of storm surge and waves as inputs. Monte Carlo simulation is used to estimate risk under a range of assumptions about future environmental and economic conditions and with different combinations of structural and nonstructural risk reduction projects on the landscape.

The CLARA model and supporting inputs were updated extensively for the 2023 Coastal Master Plan. Details for all improvements can be found in Attachment E2: Risk Assessment Model Improvements.

The improvements to CLARA modeling include:

- Integrated Compartment Model (ICM) Grid Alignment (Geospatial Updates): aligning the CLARA model grid with the ICM grid,
- Asset Database Improvements (Asset Inventory Updates): an updated structure database that captures risk-relevant attributes for structures in the coastal zone,
- Addressing Population Change (Asset Growth Model): incorporating future population change into the risk analysis and addressing the inherent uncertainty of that population change,
- Alternative Risk Measures (Updated or Alternative Risk Metrics): integrating alternative measures of risk aside from expected annual damages in dollars (EADD), and
- CLARA Model Improvements: incorporating levee/floodwall fragility, rainfall model updates, and landscape interpolation improvements.

## 3.1 ICM GRID ALIGNMENT (GEOSPATIAL UPDATES)

Aligning the CLARA model grid to the ICM grid allows for better translation of the ICM Digital Elevation Models (DEM). The 2017 CLARA grid was further delineated to ensure that each grid cell is uniquely assigned to a 2010 U.S. census block as well as a 2023 ICM grid cell. This yielded a CLARA mesh consisting of 126,174 grid points, contained within the final domain shown in Figure 3. Additionally, multiple methods were applied to minimize the variability of elevations within a CLARA grid cell,

ensuring that the elevations assigned to structures when evaluating flood effects were truly representative of the structure's actual elevation.



Figure 3. CLARA model grid domain.

### 3.2 ASSET DATABASE IMPROVEMENTS (ASSET INVENTORY UPDATES)

To provide the highest available resolution and fidelity of existing coastal assets, a cutting-edge asset database was developed from multiple public and commercial sources. Multiple asset inventories were combined to characterize residential, commercial, industrial, and public structures across the coast to improve damage estimates. The National Structure Inventory (NSI) was used as the initial basis for a new residential and non-residential structure-level dataset. Information on assets was then related to Homeland Infrastructure Foundation-Level Data (HIFLD) as well as ATTOM™, CoreLogic®, and Dun and Bradstreet commercial datasets to improve, augment, and verify the NSI and HIFLD publicly available data. Finally, through work with scholars at Purdue University and RAND, a machine learning algorithm was developed to use Google Street View imagery to more accurately assign first floor elevations to every structure (which informs damage estimates). Figure 4 shows an example of the level of detail for the asset inventory used in the Greater New Orleans area. The variety of data sources and utilization of the machine learning algorithm provide a previously unobtainable level of detail and resolution to the models.



Figure 4. Map of asset level inventory by use type for Greater New Orleans.

### 3.3 ADDRESSING POPULATION CHANGE (ASSET GROWTH MODEL)

Populations and assets located within areas projected by the ICM to convert to open water are removed from the inventories, and are assumed to relocate outside of the study region. Future master plan iterations may develop a more sophisticated implementation of this approach, which may allow for more realistic modeling of the migration of populations whose communities are threatened by sea level rise. The approach adopted for the 2023 Coastal Master Plan allows more continuous variation in growth compared to the assumptions used in the 2017 Coastal Master Plan, stratified by census demographics. It uses an overall growth rate consistent with historical data at the census block level but permits future work to normalize region wide population estimates based on commonly used forecasts.

### 3.4 ALTERNATIVE RISK MEASURES (UPDATED OR ALTERNATIVE RISK METRICS)

Focus groups and stakeholders have expressed concerns over the potential of the master plan to marginalize less affluent communities or groups due to the fact that risk has been historically measured in dollars – less affluent communities could experience the same impacts in terms of lost property, time, etc., but their losses would not be counted as great as those in more affluent communities. The 2023 Coastal Master Plan addresses this disparity through the development of a new risk measure which removes the dollar value from the risk calculation of expected annual damages (EAD) and only accounts for the number of structures lost or damaged to create a new risk

measure: expected annual structural damage (EASD). The risk measure previously known as EAD has been renamed to Expected Annual Damages in Dollars, or EADD. This new measure allows for the comparisons of flood impacts that are less sensitive to the value of the asset itself or biased towards wealthier areas. Figure 5 shows that while these measures are correlated across the coast, there is a disparity in some communities' risk.

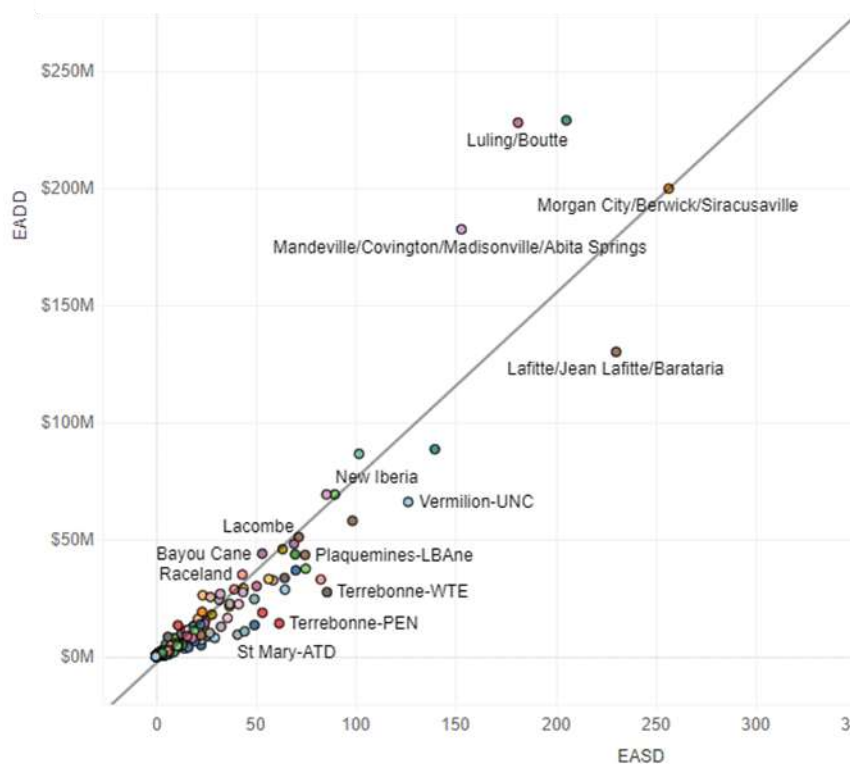


Figure 5. Correlation of expected annual damages in dollars, or EADD, with expected annual structural damage, or EASD.

### 3.5 CLARA MODEL IMPROVEMENTS

The CLARA model was originally created by researchers at RAND Corporation to support the development of Louisiana's 2012 Coastal Master Plan. The CLARA model is already well described in prior peer-reviewed and published literature, so this report does not include detailed descriptions of the basic methodological approach and assumptions. For interested readers, an introduction to the model can be found in Fischbach et al. (2012) and Johnson et al. (2013). Model improvements for the

2017 Coastal Master Plan are described in Fischbach et al. (2017), and published examples of CLARA model results can be found in Fischbach et al. (2019), Meyer and Johnson (2019), and Fischbach et al. (2017b). An updated, standalone summary of the CLARA model methodology, CLARA Model Summary Technical Memo, serves as an introduction and overview of the model has been updated for final publication with the 2023 Coastal Master Plan.

Besides improving the modeling input data, the CLARA model itself was improved to address feedback from stakeholders and to augment its capabilities to address more nuanced risk drivers. These improvements include a more realistic fragility modeling that accounts for the possibility of levee failures to occur during surge runup; rainfall model updates to better address rainfall associated with synthetic tropical storm events; and landscape interpolation improvements to reduce computational time for estimating peak surge and wave behavior.

## 4.0 IMPROVEMENTS TO NONSTRUCTURAL MITIGATION EVALUATION

The risk assessment research and improvements for the 2023 Coastal Master Plan are heavily informed by the 2012 and 2017 master plans. For example, the Risk Assessment team carried forward assumptions about nonstructural project attributes such as whether the acquisition threshold would be at 12 or 14 feet, and updated cost tables for the different project types rather than beginning with a new set of analysis from first principles. One major difference, however, is the treatment of nonstructural projects. Rather than competing specific nonstructural projects with all other projects, the 2023 approach treats nonstructural projects programmatically and attempts to define the level of risk that could be mitigated through their implementation. Multiple separate programs are available, such as FEMA's Hazard Mitigation Grant Program and HUD's Community Development Block Grant Program that could leverage this information to improve the effectiveness of their mitigation funds. Additionally, risk reduction due to nonstructural mitigation is reported in both EADD and EASD. Details of the analysis and results can be found in Attachment E3: Nonstructural Comparisons.

To help make nonstructural project definitions more useful in risk mitigation program decision-making, new community boundaries were developed. These new community boundaries have higher resolution spatial boundaries for nonstructural project areas and support improved communication of risk and damage analysis results. The 2023 Coastal Master Plan identified over 300 communities of interest on Louisiana's coast (see Figure 6).

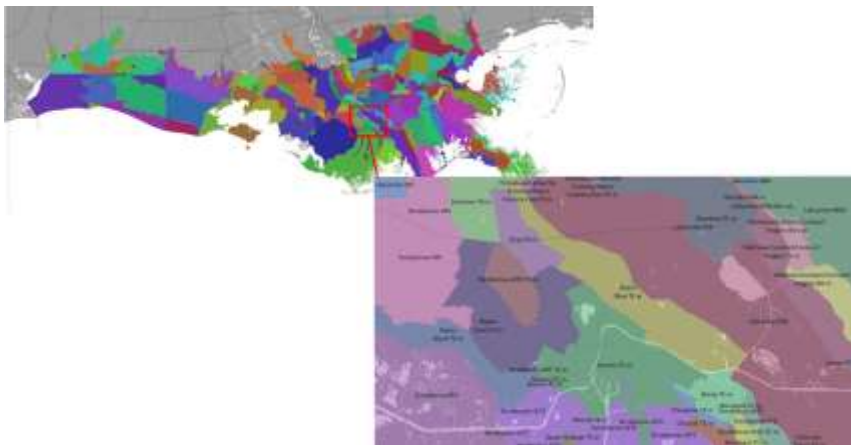


Figure 6. The 2023 Coastal Master Plan refined community definitions to increase resolution for risk.



## 5.0 CONCLUSION

Major improvements were made to the storm surge and risk models as well as the data that supports those models for the 2023 Coastal Master Plan. Example improvements include enhanced resolution, fidelity, quantity, and type of the modeled tropical events that drive risk the calculations; geospatial updates, asset inventory and growth updates, improved risk metrics, and improvements to the risk model including the inclusion of levee/floodwall fragility, rainfall model updates, and landscape interpolation improvements.